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Applicant: Ernst MERK

Title: FLEXIBLE ELECTRICAL HEATING UNIT

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TRANSMITTAL OF SUBSTITUTE SPECIFICATION

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Dear Sir:

Applicant has enclosed a Substitute Specification attached to a red ink marked-up copy of the verified English language translation of PCT International Application PCT/EP2004/005244. The red ink identifies changes to the verified English language translation which are incorporated in the Substitute Specification.

The Substitute Specification includes general revisions to correct idiomatic translational errors and to provide proper headings. The undersigned states that the Substitute Specification contains no new matter.

Based Upon: PCT/EP2004/005244

Applicant sincerely believes that this Patent Application is now in condition for prosecution before the U.S. Patent and Trademark Office.

Respectfully submitted,

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FLEXIBLE ELECTRICAL HEATING UNIT

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a flexible electrical heating unit, having a heating device with a flexible support and a heating cord inserted therein, at least one control member for a heating current arranged in at least one heating circuit and a triggering circuit acting thereon.

Discussion of Related Art

A known flexible electrical heating unit is disclosed in German Patent Reference DE 33 36 864 C2. There, a temperature intended for continuous operation is quickly reached because an increased temperature control value is set in a starting phase. Subsequently, in a transition phase, the temperature control value is lowered continuously or in stages so that no temperature drop occurs at the surface. The continuous operating temperature is not exceeded. A heating unit with a similar triggering circuit for rapidly reaching the desired surface temperature for continuous operation is also disclosed in German Patent Reference DE 41 41 224 C2.

A flexible electrical heating unit which, for example, is designed as a heating pad, is disclosed in German Patent Reference DE 44 80 580 C2. A heating current controlled by at least one control member in the form of a triac flows through the heating conductors of a heating cord. The triggering circuit for the control

member has a microprocessor, as well as a timing circuit, which is used to control the clock frequency with which a program of the microcontroller operates and which is designed as a watchdog timer for repeatedly stopping the operation of the microprocessor for a period of time which can be set between 0.01 and 3 sec., and to initialize it again. Furthermore, this known heating unit has a safety control circuit, as well as indicator lights. A fail-safe routine with error counters is also implemented in a control program. The error monitoring device is elaborate.

A further flexible electrical heating unit for the type mentioned above is disclosed in German Patent Reference DE 102 11 142 A1, in connection with which also various safety arrangements are made, and a time control circuit for switching off the heating unit is also provided, wherein switch-off times can be fixedly integrated or separately switchable. During extended operations a lowering of the temperature can also occur by appropriately programming a digital circuit arrangement in order to prevent skin burns because of continuously high surface temperatures of the heating unit. It is thus possible to provide a time-dependent reference variable step-down starting at a defined reference value temperature, or also the switching off of the heating device. Thus no detailed information is provided as to the operating phases in which appropriate controls of the heating output are performed.

SUMMARY OF THE INVENTION

One object of this invention is to provide a flexible electrical heating unit of the type mentioned but in which heating conditions at the surface of the heating unit, or of the support, can be set with a higher degree of comfort by a user, wherein the time control circuit simultaneously can be used for meeting safety criteria.

This object can be attained with a triggering circuit having a time control circuit, by which a heating output can be controlled or regulated which, for generating a starting temperature at the surface of the support during a preset initial length of time, is increased in comparison with a subsequent continuous operating phase. During the continuous operating phase at most one heating output permissible also for unmonitored operation is set to cause a lower surface temperature of the support than during the initial phase, or wherein a switch-off takes place after the initial length of time.

If, for example, a relatively large heating stage is selected by a user for a correspondingly high surface temperature, this is detected by the control circuit and, by the time control circuit, a relatively large heating output is initially released; but only at a level which is acceptable to the safety requirements of the heating unit and the temperature tolerance of a user in order to prevent endangerment of his health, for example. If the initial heat requirement of the user is substantially satisfied, the heating output is reduced to a degree acceptable for continuous heating operations.

Alternatively, a complete switching off of the heating output can occur after the initial time period, if a user desires this from the outset and selects a possibly provided appropriate program.

There is an advantageous control or regulating option of the heating output that results from designing the triggering circuit so that the size and/or length of the increased heating output in the starting phase is controlled or regulated as a function of a heating output manually selected for the continuous heating phase, wherein the desired temperature is related to the continuous operation, and the progression of the heating output in the starting phase is set as a function thereof to an appropriate value. For example, it is possible to reach an appropriate temperature level relatively rapidly with a correspondingly high permissible heating current in a starting phase of the initial length of time and then, during the further initial length of time, to maintain it on the same level or to permit it to drop slowly or in stages in order to make a transition to the heating output level of the continuous operating phase, or to perform a complete shut-off toward the end of the initial length of time of, for example, 60 or 90 minutes.

In one construction, the time control circuit acts by an output signal on an output-actuating circuit arranged in the triggering circuit, by which the control member can be triggered.

In order to achieve, in particular in the initial phase, a progression of the temperature which differs from the continuous operation, a reference variable can be superimposed on the output signal of the time control circuit by charging it with a reference variable.

In a further embodiment, the triggering circuit has an insulation monitoring stage for an insulation located between the heating wires contained in the heating cord, a monitoring stage for the interior temperature of the housing, or a limiting stage, or a combination of at least two of these stages, and the amount and/or length of the generated heating output caused by the effect of the time control circuit is limited in case of a faulty status discovered in at least one of the stages, or if the heating output is completely shut down.

In a further embodiment, a further control member, which can be triggered by the triggering circuit, is arranged in the heating circuit and is triggered in case of a faulty state to limit, reduce or shut off the heating current, wherein at least one output signal of the stages can be used for triggering the further control member.

The construction and the function are also favored if the output signal of the time control circuit is supplied to at least one stage, and the at least one stage is embodied so that, as in an abnormal state, it acts on the control member, and/or the further control member, for limiting, reducing or interrupting the heating current, or

that the output signal is applied directly to the further control member for limiting, reducing or interrupting the heating current.

In a reversed manner, the steps are advantageous for a simplified construction wherein the output of at least one stage is connected with the input of the time control circuit, and wherein, upon receiving an output signal from the stage, the time control circuit itself transmits an output signal for limiting, reducing or interrupting the heating current.

Also, dependable functioning can be achieved by switching off the electrical supply voltage, and if the time control circuit is brought into an active electrical connection with a switch of the energy supply device of the heating unit, with the triggering circuit, or a component of the triggering circuit, or directly with the further control member.

Advantageous setting or control options are also achieved if the progressions of the heating output for affecting the surface temperature with respect to size and/or length are stored in a memory as a function of a manually selected output stage or type of operating application, and can be called up for controlling and adjusting the heating output. The various progressions of the heating output useful for a desired heating stage or a desired type of heating operation can then be programmed, in particular in a microprocessor or a microcomputer or micro-controller or ASIC, and can also be reprogrammed or adapted. It is thus possible to take

different embodiments of the heating unit, for example a heating pad, heating blanket or heated mattress pad, into account in a relatively simple manner.

Here, a further refined control option results if further progressions are stored in the memory in connection with an output stage change-over during an operating phase, and can be called up as a result of the change-over.

For informing a user more accurately regarding the device status, steps are also advantageous wherein the time control circuit is connected with an indicator device for the status of the time control circuit and/or the device functions.

Additional safety for the operation of the heating unit is obtained if a parallel branch which is located parallel with a control branch of the heating circuit which has the at least one control member, a higher order safety shut-off device is provided for shutting off the heating unit, in case of a dangerous situation.

The step wherein the heating cord is constructed so that a safety shut-off occurs in case of an excess temperature contributes to safe functioning. In this case, the construction can be advantageously such that the shut-off is triggered in case of a local excess temperature (hot spot). The basic function can be achieved by a sort of current safety device and/or temperature safety device. With flexible heating units the reaction or trigger temperature is preferably located in the range between 110°C and 160°C, with especially flexible heating units a different reaction temperature can also be suitable.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention is explained in greater detail in view of exemplary embodiments, making reference to the drawings wherein:

Fig. 1 is a schematic block representation of a first embodiment of a heating unit;

Figs. 2 to 4 each shows an embodiment of the heating unit in block representations; and

Fig. 5 shows an example of two different temperature progressions.

DESCRIPTION OF PREFERRED EMBODIMENTS

An electric heating unit represented in Fig. 1 has a flexible heating device 10 arranged in a heating circuit 17 and has a flexible heating body or support with a heating cord arranged therein and a triggering circuit 20 for controlling or regulating a heating current iH flowing in the heating circuit 17. The heating unit can be connected via a power switch 30 to a main current supply 33, for example the electrical network, wherein the supply current is limited by a current limiter 31, and a suitable low voltage for the triggering circuit 20 and, if needed, for other installations, is made available by a voltage supply element 32.

A heating cord of the heating device 10 is constructed in the customary manner and preferably has two heating conductors extending coaxially or side-by-side, which conduct the heating current in opposite directions for reducing an

electromagnetic field, and are separated from each other with the aid of an insulation having, for example, a negative resistor temperature progression (NTC resistor). For detecting the insulation resistance, an insulation sensor device 11 is arranged at least partially in the heating circuit 17. Following the heating device 10, the heating circuit 17 is separated into a control branch 17.1, having the control member 12, and a parallel branch 17.2 extending parallel with it, in which a safety circuit 14 for shutting off the heating unit is arranged, such as if a dangerous situation arises in the heating device 10, such as a short circuit, for example.

A further control member 13 is arranged in the control branch 17.1, by which the heating current iH can be limited, or even completely shut off, in case of a failure, wherein its triggering also occurs via the triggering circuit 20. The two control members 12, 13 are preferably designed as semiconductor switching members, for example as thyristors, or triacs, or switching transistors. Reference regarding the details of the embodiment of the insulation sensor device 11, the control members 12, 13 with their triggering, as well as the safety shut-off device 14, is made to German Patent Reference DE 102 11 142 A1, in which details of a suitable design are disclosed. Accordingly, a diode is arranged between the ends of the heating wires remote from the connecting cable, by which a half-wave of the heating current iH is blocked during normal operations. If current of a negative half-wave also flows, this means that the diode is shorted out through the insulation. Because of the negative

temperature progression of the insulation, this electric current component is a function of the temperature of the heating cord, so that it is possible to draw conclusions regarding the temperature of the heating cord via the insulation sensor device 11, wherein spot temperature rises (hot spots), in particular because of a sharp kink, result in a considerable temperature rise in the blocking direction of the diode, which reaches a maximum in case of a short circuit in the heating conductors.

In case of a short circuit in the heating conductors, the safety shut-off device 14 in particular responds, which is fed via a further diode arrangement which lets the short circuit current through. The short circuit current leads to a large temperature rise in resistor elements provided in the safety circuit 14, which are in thermal contact with a temperature safety device and trigger it, and thus interrupt the supply current for the heating unit.

As essential components, the triggering circuit 20 has a time control circuit 21 with an indicator device 21.1, as well as an output-actuating circuit 25 connected with the indicator device 21.1, through which the control member 12 is triggered. The triggering circuit 20 also has an output stage switch 22 as an essential component, by which a user can select a desired temperature. The triggering circuit 20 can also contain a monitoring device 23 for the interior housing temperature of a switch housing, and/or a monitoring circuit in the form of a watch dog device or of a redundant triggering circuit for the further control member 13. The triggering

circuit 20 can be assembled in part by a micro-controller or microcomputer, or a special integrated circuit arrangement (ASIC solutions).

The time control circuit 21 has several functions, which can be provided by one or several internal programs. Here, in one embodiment, during an initial time period which is preset or can be fixedly preset (cannot be changed by the user) of preferably between 30 and 120 minutes, for example 60 or 90 minutes, initially a heating output, which is clearly increased in comparison with a selected temperature stage, is generated via the output-actuating device connected to the time control circuit 21 and the control member 12, wherein in a starting phase of the initial time length Delta ta a steep rise of the surface temperature of the heating body or support takes place up to a defined level, in which the safety requirements are dependably maintained. Then, with an appropriate control or adjustment of the heating current iH, the heating output remains at this level for a preset length of time or is slowly reduced. Toward the end of the initial time length the heating output, or the heating current iH, is then controlled or regulated so that a permitted temperature at the surface of the support, which can be selected by the user for a longer subsequent continuous operation phase without a fixedly preset end, or also by a time control, of 50°C or 60°C, for example, is not exceeded in order to assure safe operation of the heating device 10 even under unsupervised conditions (for example while sleeping), and also to assuredly prevent health risks, even to a sensitive user.

An example of the progression of the temperature at the surface of the support, which is controlled or regulated by means of the above steps, is represented in Fig. 5. A maximum surface temperature T_{omax} (in the present case 85°C), which in no case may be exceeded, is reached, for example, after 90 min. or sooner. Thereafter, a lowering of the temperature takes place in accordance with a defined reference variable to a temperature T_{OD} (of, for example 50°C), which is permissible for continuous operation (over several hours), which is also permissible during unsupervised operation (for example during sleep). An intermediate temperature T_z (for example of 65°C), which lies between the maximum surface temperature T_{omax} and the permissible continuous operating temperature T_{OD} is at most exceeded for a length of time Delta tz (for example two hours).

The control or regulation of the heating output by the heating current iH can also take place so that, following the desired progression of the temperature during the initial length of time Delta ta, complete shut-off takes place, wherein the temperature is reduced in accordance with the progression T_{OA}. Such a selection option can be provided, for example, in the output stage switch 22, or a corresponding operating unit.

Also, it is possible to provide an interval output control or regulation for the above mentioned heating programs, for example for a therapeutic treatment, while observing a maximum temperature limit value after 60 or 90 minutes, for example.

The progression of the output control or regulation, and of the temperature caused thereby on the surface of the support, complies with a selected temperature stage and is preferably also suitably controllable as a function of a change of a temperature stage, for example as a function of the length of time since switch-on and/or of the selected new temperature stage with respect to the previous temperature stage. It is also possible to provide a pre-selection option of the mode of operation in the operating unit or the output stage switch 22, such as an interval-like heat treatment for therapeutic treatments, or a sleep mode, for example.

The output stage reduction can take place continuously or in stages in accordance with a preset program progression.

For causing a switch-off, for example after 60 or 90 minutes, it is possible to let an output signal of the time control circuit 21 act on the output-actuating circuit 25, on the monitoring circuit 24, the power switch 30, on the monitoring device 23 for the interior housing temperature, or on the insulation sensor device 11, if required along with an insulation monitoring stage 11.1 provided in the triggering circuit 20, or on combinations of these components. In the progression of this the control member 12 and/or the further control member 13 can be addressed. It is also possible to perform a limitation or reduction of the heating output via one or several of these components.

The various progressions can be stored in a memory, for example in the form of progression curves, or tables, wherein they are automatically selected corresponding to the temperature selection via the output stage change-over switch 22, or the operating unit. In particular, it is thus safely assured that preset or predeterminable threshold values are maintained in accordance with recognized safety criteria. The operational states of the time control circuit 21, as well as other operational states of the heating unit, can be represented on the indicator device 21.1 in a manner which the user can understand. The selection of the temperature stages, or of a mode of operation, can also thus be represented to the user.

As shown in Fig. 1, the time control circuit 21 is in bi-directional connection with the supply element 32 in order to provide the shut-off of the latter, if required. The time control circuit 21 is bi-directionally connected with the output stage change-over switch 22, so that it can detect the temperature selection and, on the other hand, can also cause the switch-off of the output stage change-over switch, for example. Furthermore, the output signals of the time control circuit 21 can act via the monitoring device 23 for the interior housing temperature and the monitoring circuit 24 on the further control member 13 for limiting, reducing or switching off the heating output. In the other way it is also conceivable that the monitoring device 23 for the interior housing temperature and the monitoring circuit 24 act with their assigned control signals on the time control circuit 21, which then itself acts by an

appropriate output signal on the control member 12 or the further control member 13 for limiting, reducing or switching off the heating output.

In a further embodiment of the electrical heating unit, such as represented in Fig. 2, the components identified with reference symbols corresponding to Fig. 1 have corresponding functions, so that reference is made in view of the above explanations. With the exemplary embodiment in accordance with Fig. 2, two heating cords, which can be separately controlled, are placed into the flexible support, for example, so that a first and a further heating device 10A, 10B result. Preferably, the two heating devices can be controlled via respective heating circuits 17 in the same way as in the previous exemplary embodiment, wherein portions of the heating circuit 17 can also be assigned to the two heating devices 10A, 10B together. The triggering circuit 20 correspondingly has an output stage switch 22, or an operating unit, by which both heating devices 10A, 10B can be separately selected in regard to the temperature. It is also possible with the time control circuit 21 to separately preset different progressions of the two heating devices 10A, 10B. This triggering control 20 also has a monitoring circuit, for example, with a watchdog circuit or a redundant control circuit for the further control member 13, as well as a monitoring device 23 for the interior housing temperature, which can be connected in a suitable manner with the time control circuit 21, as previously explained.

The time control circuit 21 contains a clock frequency change-over circuit 21.1, a frequency divider 21.2, which can be changed over, as well as a logical output device, which makes possible different output signals for triggering the power circuit breaker 12, so that a separate output-actuating circuit 25 is not required.

When changing the output stages, it is possible via the clock frequency change-over circuit 21.1 or a change-over of the frequency divider 21.2 to preset a change of the time control circuit via the output change switch 22 by the time control circuit 21, wherein a combined utilization of the clock frequency change-over circuit 21.1 and the frequency divider 21.2 can also be provided. Thus the output change-over can also be realized by a mechanical output change-over device acting directly on the time control circuit 21. The user sets the temperature stage by the output change switch 22 together with the heating device 10A, 10B. The clock frequency change-over circuit and/or the frequency divider 21.2, for example, are simultaneously activated in order to exert an influence on the time control device.

Because the time control circuit 21 has signals from the monitoring device 23 for the interior housing temperature, the monitoring circuit 24 and/or the insulation sensor device 11, namely via the logical output device 21.4, can detect the impermissible state, for example when the interior housing temperature or the heating cord temperature are exceeded, and interrupts the heating current iH by the control member 12, or reduces it to an effective value. Here, too, the user can be supplied

with appropriate status information by the indicator device 21.1 of the time control circuit 21.

It is also possible to put out an acoustic indication, for example a warning signal.

With the embodiment in accordance with Fig. 3, the components corresponding to the exemplary embodiment in accordance with Fig. 1 are also identified with the same reference symbols. Again, reference is made to the embodiment in accordance with Fig. 1, as well as to the embodiment in accordance with Fig. 2, for their operation and functioning. A temperature regulation is performed in the embodiment in accordance with Fig. 3 because an actual value is picked up in the heating circuit 17, namely in the control branch 17.1, by a measuring circuit, for example a measuring resistor 15, and is supplied via an actual value circuit 27 to an input of a comparator embodied in a control stage 29. A primary reference variable, made available in particular by the output stage change-over switch 22, is supplied to a further input of the comparator in order to trigger, by a reference variable/actual value comparison and an appropriate triggering circuit with an output divider, the control member 12 to regulate the temperature by affecting the heating current iH. Also, the control stage 29 which, for example, is embodied as a micro-controller, has signals from the insulation sensor device 11 via the insulation monitoring stage 11.1, the monitoring device 23 for the interior housing temperature

and/or the monitoring circuit 24, wherein in the present case an output of the monitoring circuit 24 is connected directly with the further control member 13.

Now, the time control circuit 21 can, by appropriate output signals, affect the reference variable in particular via the reference variable circuit 26 and via a reference value charge device 26.1 in order to influence the heating output as a function of the length of time, or the heating current iH via the control stage 29, particularly in the way explained in connection with the first exemplary embodiment. Also, the time control circuit 21 triggers the insulation monitoring stage 11.1, the monitoring device 23 for the interior housing temperature, a zero voltage triggering device 28 for assuring defined triggering times, as well as the monitoring circuit 24 and also the power switch 30, wherein the triggering options can also be embodied only in part. Diverse intervening options in the regulation of the temperature are made possible with these steps. Here the user sets the desired temperature, or an operating mode, via the output stage switch 22, or an appropriate operating unit, by which the user presets the reference temperature variable or a progression of the reference temperature variable. The electrical voltage supply can also be turned off, if required, by the time control circuit 21 acting on the power switch 30. The progressions described in connection with the first exemplary embodiment can be controlled or adjusted by the at least partial triggering of the remaining components, and a limitation, reduction or switch-off of the heating current iH can be caused.

With the embodiment represented in Fig. 4, in which the corresponding components are identified by the same reference symbols as in the preceding exemplary embodiments, two bi-metal regulators 16.1, 16.2, which are switched in parallel with each other, are arranged in the heating circuit 17 following the heating device 10, downstream of which again an insulation sensor device 11 or, in its place, a further bi-metal regulator or limiter, or a temperature safety device, are connected. Then the heating circuit 17 again branches off into the control branch with the control member 12, and into the parallel branch 17.2 with the safety shut-off 14. On the input side, the time control circuit 21 is connected to the supply element 32, the output stage switch 22, the monitoring device 23 for the housing temperature, as well as the insulation sensor device 11, or a component replacing it. On the output side, the time control circuit acts on the output-actuating circuit 25, the supply element 32, the power switch 30, the control member 12 and/or the output stage switch 22. The output-actuating circuit 25 and the monitoring device 23 for the housing temperature are supplied by the supply element 32. Corresponding progressions as described in connection with the previous embodiment can be at least partially controlled by the time control circuit 21, which is preferably also preset in programs.

The regulation of the heating current iH by the two bi-metal regulators 16.1, 16.2 occurs similar to the way that initially the heating current iH flows through both bi-metal regulators 16.1, 16.2 until the first bi-metal regulator 16.1 is switched

off when a lower temperature threshold of, for example 50°C, is exceeded. Then the heating current only flows through the other bi-metal regulator 16.2 until an upper temperature threshold preset in it of, for example 75°C, is reached. Then the heating current iH is completely interrupted. Because the other bi-metal regulator 16.2 is designed with an automatic lock and therefore remains in the opened state, the heating current iH only starts to flow again when the temperature falls below the lower threshold, and an adjustment to this temperature is made following the initial time length. It is then possible with the further bi-metal regulator 11 or the control member 12 to set a limitation, reduction or shut-off of the temperature up to the lower temperature limit. During this the temperature desired by the user is set via the output stage switch 22, as well as via the progression determined by the time control circuit 21, as described in connection with the preceding embodiments. Also, the shut-off of the heating current iH, for example, can take place by triggering the power switch 30 with an output signal from the time control circuit 21. The heating unit in accordance with this embodiment also provides temperature updating adapted to demands of a user, wherein various safety criteria can be assuredly maintained.

Switch-off via the described time control circuits takes place with uni-polar or multi-polar switch-off devices, for example, while switching off by the user takes place, for example, in an omni-polar manner from the power supply in a known way.